Impacts of Different Mobile User Interfaces on Student Satisfaction for Learning Dijkstra's Shortest Path Algorithm

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Abstract—**This paper describes an experimental study of university students learning Dijkstra's shortest path algorithm on mobile devices. The aim of this study is to investigate and compare the impacts of two different mobile screen user interfaces on student satisfaction upon learning this technical topic. A mobile learning prototype was developed for learning Dijkstra's shortest path algorithm on Apple iPhone 4s operated on the iPhone operating system (iOS) and Acer Inconia Tabs operated on an Android operating system. Thirty students who are either currently studying or had previously studied the course "Computer Networks" were recruited for the usability trial. At the end of each session, student satisfaction with respect to their satisfaction with the two mobile devices was measured using QUIS questionnaire. Although there is no significant difference in student satisfaction between the two different mobile screen interfaces, the subjective findings indicate that the Acer Inconia Tab gained higher scores than the Apple iPhone 4.**

Index Terms—**Dijkstra's shortest path algorithm, mobile devices, mobile user interface, small screen interface, user satisfaction.**

I. INTRODUCTION

Mobile-based learning technology is a new generation of e-learning technology that permits learners to carry out learning activities and practice course content more frequently, anytime and anywhere, through mobile devices using smart phones, tablet PCs and PDAs [13],[16],[17]. Although previous research has provided findings with regards to the capabilities of mobile devices in learning and teaching, research is still required to investigate the impacts of small screen devices on user satisfaction when used in mobile-based instructional applications, in view of the different screen sizes of mobile devices [12].

The main objective of this paper is to investigate and compare the impacts of different mobile user interfaces on student satisfaction, using a mobile-based learning prototype. A second objective is to design and develop a usable mobile-based learning prototype based on the identified usability and user interface design guidelines presented by [9] and [10]. The developed prototype focused on designing mobile-based course content for Dijkstra's shortest path algorithm. Dijkstra's shortest path algorithm is a technical subject, which is taught to computer science students. The prototype was developed for two different touch-based mobile devices, the Apple iPhone 4 and the Acer Inconia Tab. The computer science students generally need to fully comprehend this topic in order to master the theoretical concept and practice of the subject [13]. When the Dijkstra´s shortest path algorithm is presented on small screen devices with different processing capacities such as limited storage and performance restrictions, designers and developers need to incorporate an appropriate design strategy to assist students learn this complex concept [3],[4],[7].

II. LITERATURE REVIEW AND RELATED WORK

Designing an effective user interface for a mobile-based application is strongly emphasized by various mobile learning studies [9],[10],[13]. As such, usability of a mobile-based application is one of the most important attributes that should be considered when designing and developing a mobile-based learning application [9],[10]. An efficient user interface for mobile device is essential to create a usable and effective mobile-based information system because it helps increase user satisfaction and provides greater interactivity for persons using mobile and handheld devices for learning.

A. User Interface Design for Mobile Applications

Reference [9] presents four guidelines to desig a usable interface for mobile-based applications:

1) Small Screen Display

The small screen size of mobile devices represents challenges with regards to designing content effectively and organizing as much information as possible on a small screen display [21]. The restriction of small screen devices gives rise to other restrictions during the design phase of a usable mobile-based learning application [9],[21]. For instance, small screen displays trigger a more difficult reading process that directly impacts the normal pattern of eye movements and indirectly influences human interactions [25]. The information and content displayed on mobile-based application screens must consider reading speed, and the effect smaller text has on it. As a result, information should be organized into small chunks to provide the information in n more effective manner [22]. Frequent scrolling and the number of touches by the users should be reduced. The height and width of an application screen page should not exceed the screen size of the target mobile devices [9].

2) Relevant Information Display

Presenting irrelevant information not only can confuse novice learners [8]. Relevant information must be displayed on each page of the application because of the restrictions and limitations imposed by the screen display size [9]. The most important information should be located at the right top corner to ease the readability. Empty and blank spaces should be designed with great care to avoid misleading or confusing users [9].

3) Navigation

Success or failure of a usable mobile-based application displayed on small screen devices is determined to a great degree by the selection of appropriate navigation structures [22]. Consistent navigation can support and maintain learner satisfaction while learning on a mobile learning application [9]. [23] suggests reducing complicated navigation by using simple menu options, which are already used in existing mobile devices, which will make users more comfortable using a more usable navigation method. Another two important considerations that can make navigation more fluid are decreasing the number of touches by users and changing the text input method by selecting the text from a menu list [8],[23].

4) Consistency

Consistency is one of the most important and fundamental usability principles to consider when designing a usable interface [11]. In particular, consistency of mobile contexts is very important because of the restricted screen size of mobile devices [9]. Moreover, consistency is defined by [24] as a cover for interface design and the task usefulness structure of a learning application. Thus, information needs to be located in the same locations in the interface to trigger consistent user actions [9]. For instance, similar buttons must be positioned in the same place on every page of the application.

B. Usability

Usability defines the quality of the user interface design and interaction of an application. Usability can be measured by the quality of learner experience during the interactions with the user interface of an application [11]. The advantages of usability are: (i) reducing the time and cost of training, (ii) reducing the errors that the user encounters during their interaction with the system, (iii) increasing learning performance and user satisfaction, and (iv) improving the quality of interaction with the interface [6],[13],[14],[15]. Thus, a set of design principles should be followed to provide an acceptable mobile-based learning application in terms of usability. We also took user interface limitations of a mobile-based learning applications such as small screen size, poor resolution, limited storage facility and lower processing capacity into account [4],[7],[26]. Finally, the mobile user interface must be designed in a simple way without any complexity, the size of output files must be reduced as much as possible, and the application must not involve high processing capacity.

C. Mobile Technolog

D. y and Mobile-based Learning Application

In developing mobile-based learning applications, some research studies have produced course content applications based on small screen devices. Four mobile-based course content learning applications have been developed by [9],[13],[19],[20].

According to [19], Adobe Flash CS3 was deployed to develop an application for learning English as a second language. This provides a reference to integrate two components in developing a mobile learning application on content and interface design. Content should be divided into various chunks so that each chunk represents a one-interface screen page. In terms of the user interface, [19] had an optimized screen resolution via brightness and screen contrast that was controlled by the users. Adobe Flash CS3 was used to give learners full control to select and play each lesson slide by slide. At the end of the lesson, students could repeat the current slides, proceed to the following lesson, or complete the exam questions. Meanwhile, he used native speaker voices to improve the learners' listening experience, associating sounds and texts to assist learners. In order to accelerate the learning process, the researcher also used exercises to motivate and enhance learner performance upon concluding each unit. The results indicated that the project could improve learner satisfaction by permitting students to learn at any place and any time at individual pace with ease of use to enhance their pronunciation, especially their listening skills [19].

Reference [9] presented usability guidelines that focus on the user interface in terms of usability theoretical frameworks, possible restrictions and the unique properties of small screen interfaces. Three categories for usability of a mobile-based learning application were formulated, consisting of user interface design, human interaction and user analysis. These three categories, in turn, are supported by 10 golden usability guidelines for designing an effective, user friendly and usable mobile interface to support learning through mobile and handheld devices. An application was developed which is called Mobile Learning Course Manager (MLCM) to demonstrate the impacts of the proposed usability guidelines. The user interface of MLCM can be deemed as usable because it is learner centered, which was a primary consideration for designing the application. The application provides announcements, assessments and a timetable, three useful main menu options for registering MLCM [9],[5].

Reference [13] presents a study of User Interface Design (UID) principles and requirements for utilizing mobile devices as instruments for mobile learning. This study is supported by a suitable design architecture and learning theories. The objective of the study was to examine the design principles and requirements required to develop a course content application based on mobile devices [13]. Besides, the second objective is to produce a course content mobile-based learning prototype for System Analysis and Design (SAD) course for students. This is based on the principles, guidelines and requirements, which were identified as a powerful design tools for mobile-based applications. Finally, a survey was used to investigate the usability level of this prototype among the students. The findings show that the learners perceive the developed mobile application as usable, according to usability metrics [13].

III. RESEARCH METHODOLOGY

A. Design and Development a Mobile Prototype

Based on the literature, we have developed a mobile-based application prototype for learning the concept of the technical subject (Dijkstra's shortest path algorithm). The prototype started with an accompanied start-up page. The designed page and its components appear on the start-up page to attract learner interest, enhance learning assessment and provide instruction for indoor and outdoor learning activities. The prototype serves the purpose of learning and practicing the technical subject, namely Dijkstra's algorithm, to computer science students in a way to facilitate their learning. The content pages are presented in textual and animated formats, with some simple activities designed by the researchers. The two mobile devices with different screen displays are Apple iPhone 4 as a mobile phone (operated on iPhone operating system (iOS), 640 x 960 pixels screen display), and Acer Inconia Tab as a tablet PC (operated on an Android operating system, 1280 x 800 pixels screen display).

B. Discussion on Design and Development of the Mobile Learning Prototype

Figure 1 shows the introductory page, where users are shown an attractive introductory page and attractive buttons. Each button shows an action that each router has to perform while working on the network. The user will then be directed to the main content page of the specific action which presents basic information about the action and a main menu. The learning atmosphere is friendly, and the content page is colorful and intuitive. The main page contains an animation to encourage learners to learn about the actions. Figure 2 shows that the 4 buttons address "Learn & Example", "Try & Test", "Previous" and "Next", so that learners can access all steps of learning and a textual context to describe the action for students via some simple sentences. Users can select the options to 'learn about the action', followed by 'view an example' or 'test and practice the action,' to evaluate themselves by touching the buttons. 'The design allows students to have full control of the mobile learning prototype and the student lessons. After touching a button, the first page will direct students to a new content page. Based on which step is chosen, materials and contents are presented in a proportionate form so that the user can have greater interactions. Keeping the user working in an interactive manner with the prototype is our main concern [27].

After getting acquainted with the concept of Dijkstra's shortest path algorithm, users are allowed to enter the following session and learn the subject via an appropriate example. The prototype delivers the information in an animated format. Both animation and text are used to motivate users to learn more about the subject. According to the study's aim and objectives, learners are given autonomy to control this phase of learning. Learners can evaluate themselves in the final option of this application, which allows learners to grade their performance and obtain feedback provided by the application. Animations are provided in movie clips in the content pages. Movie clips are used in this mobile-based learning application to reduce the size of the output file. The navigation is simple, user friendly and clear, and it allows navigation from any page to any other particular section and back to the main menu [27]. Despite its design and varieties of animations and buttons, an important design priority was to design a quickly-loading main page. All pages were produced to fit the screen size of the two separate small-screen mobile devices (either on Apple iPhone 4 mobile phone or Acer Inconia Tab tablet PC) before offering the prototype to the students for testing.

During the design stage, we highly consider the restrictions of small screen devices such as limited and different small screen size, as well as poor resolution during the design and development of the prototype [4],[7]. The final prototype was then presented employing these two distinctive mobile devices to computer science students as a mobile-based interactive learning and prototype to support their understanding of the subject matter and practice in their field of study. In the design phase, procedural steps define the requirements of learning application. The validity of the content comes from renowned instructional book references such as [1],[2]. Usability guidelines for designing and developing an interactive learning application based on a mobile technology environment were incorporated [6],[9],[10]. Design requirements of a usable application also include learning a technical subject based on small screen devices. Another important consideration is the usability of the learning application, as presented by [9], [10] and [11]. These design requirements were incorporated into the design and development of the mobile learning application for both mobile devices.

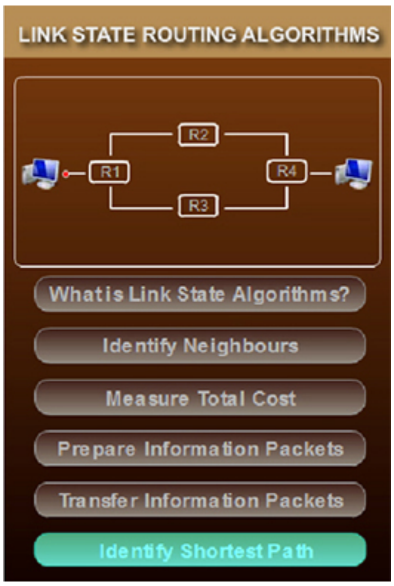

Figure 1. Intro page of the mobile application

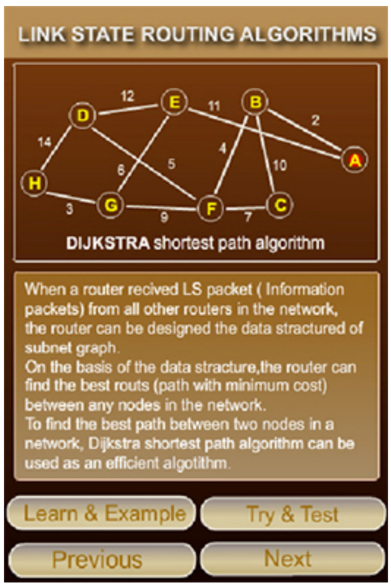

Figure 2. Main content page of link state routing algorithms

IV. EXPERIMENTAL STUDY

In this study, we conducted a user evaluation of the learning prototype with 30 participants with computer science backgrounds. Each of the participants was briefed to test the two different targeted mobile devices. A single task was planned to evaluate the impacts of different mobile devices on the level of user satisfaction of the prototype. We asked each participant to evaluate the prototype's performance on learning Dijkstra's shortest path algorithm with their test performance. The participants were given 5 to 10 minutes to work with the prototype before evaluating the prototype and taking the test. Subsequently, each of the participants was asked to perform a single task on another mobile device. The order of the test instruments (Apple iPhone 4 and Acer Inconia Tab) were randomly chosen to avoid bias in the experimental design.

After finishing the task on each mobile device, the participants were asked to complete a usability questionnaire to evaluate the level of user satisfaction with the mobile-based prototype for each mobile device. This questionnaire was based on the QUIS (Questionnaire for User Interaction Satisfaction) (Chin, 1998). The questionnaire consists of a set of validated questions to evaluate the level of each student's satisfaction with the mobile learning prototype. The data collected from the usability (user satisfaction) questionnaire were defined, based on usability and user satisfaction metrics. The questionnaire consists of 5 metrics, which include 'overall reaction to the prototype', 'screen', 'terminology and system information', 'learning' and system capabilities'. The students need to rate each question on a 7-point semantic differential scale. There is also another option (NA= not applicable) for those who believe the question is not relevant to the prototype. Half of the participants tested the prototype on the Apple iPhone 4 as the first device, and second half started the testing with the tablet device (Acer Inonia Tab) to ensure a high level of accuracy and avoid bias of the test results. After each session, the data were analyzed to extract appropriate information. To analyze the results, we used the SPSS 16 statistical analysis software to run the analysis. Paired-Samples T-Test was used to analyze the test and QUIS questionnaire results.

V. RESULTS

The data gathered through QUIS questionnaires which were completed at the end of each testing session are summarized and shown in Table I. User satisfaction with both mobile devices (Acer Inconia Tab and Apple iPhone 4) was measured on a 7-point Semantic Differential Scale. Each mobile device with the two different interface designs was classified by the users according to 5 different categories as mentioned below (see Table 1).

As mentioned previously, a Paired-Sample T-Test was used to analyze the data gathered from the QUIS questionnaire in terms of user satisfaction, (see Table I). Table II provides the usability items which show significant differences between both Acer Inconia Tab and Apple iPhone 4 mobile devices.

As shown in Table I and Table II, the tablet PC and mobile Phone have no significant differences in terms of "simple and natural sentences" and "tasks can be performed in a straight-forward manner". Both have an average mean (5.93 and 5.87), mean difference (0.000 and 0.000), T-value (0.000 and 0.000) and P-value (1.000 and 1.000). Furthermore, the Mobile phone (Apple iPhone 4) scores better in terms of "efficiency" and "showing the mistakes" on the basis of user satisfaction. In other words, except for the questionnaire's 4 usability items which are addressed above, the tablet PC achieves overall better scores compared to the mobile phone (Apple iPhone 4), based on the QUIS results.

TABLE I.
PARTICIPANT SATISFACTION RATING FOR MOBILE DEVICES

Question	Mobile devices	N	Mean	Std. Deviation	t	P value	Mean difference
Category: Overall Reaction							
Terrible-Wonderful	Acer Inconia Tab	30	5.97	0.809	4.558	**0.000	0.800
	Apple iPhone 4	30	5.17	1.020			
Difficult-Easy	Acer Inconia Tab	30	6.30	0.794	2.878	**0.007	0.667
	Apple iPhone 4	30	5.63	1.159			
Frustrating-Satisfying	Acer Inconia Tab	30	6.13	0.900	4.136	**0.000	1.067
	Apple iPhone 4	30	5.07	1.437			
Rigid-Flexible	Acer Inconia Tab	30	5.73	1.202	1.838	0.076	0.400
	Apple iPhone 4	30	5.33	1.213			
Dull-Stimulating	Acer Inconia Tab	30	5.53	1.592	0.226	0.823	0.033
	Apple iPhone 4	30	5.50	1.503			
Unfriendly-Friendly	Acer Inconia Tab	30	5.93	1.530	1.884	0.070	0.367
	Apple iPhone 4	30	5.57	1.501			
Ineffective-Effective	Acer Inconia Tab	30	6.00	0.910	2.763	**0.010	0.333
	Apple iPhone 4	30	5.67	0.959			
Inefficient-efficient	Acer Inconia Tab	30	5.97	0.718	-0.843	0.406	-1.700
	Apple iPhone 4	30	7.67	10.864			

Category: Screen							
On screen information Confusing-Very clear	Acer Inconia Tab	30	6.20	0.961	2.765	**0.010	0.433
	Apple iPhone 4	30	5.77	0.971			
Interaction Difficult-Easy	Acer Inconia Tab	30	6.20	0.761	3.593	**0.001	0.967
	Apple iPhone 4	30	5.23	1.406			
Sequence of Screen Difficult-Easy	Acer Inconia Tab	30	6.10	0.995	1.439	0.161	0.267
	Apple iPhone 4	30	5.83	1.053			
Reading Items Difficult-Easy	Acer Inconia Tab	30	6.33	0.802	4.227	**0.000	1.300
	Apple iPhone 4	30	5.03	1.497			
Easy to Find Learning Steps Difficult-Easy	Acer Inconia Tab	30	6.17	0.791	1.409	0.169	0.333
	Apple iPhone 4	30	5.83	1.177			
Multimedia Elements Useless-Useful	Acer Inconia Tab	30	5.80	0.887	1.361	0.184	0.200
	Apple iPhone 4	30	5.60	1.037			
Navigate Among the Screen Difficult-easy	Acer Inconia Tab	30	6.30	0.750	2.670	**0.012	0.633
	Apple iPhone 4	30	5.67	1.241			
Category: Terminology & System Feedback							
Simple and Natural Sentences Never-Always	Acer Inconia Tab	30	5.93	0.828	0.000	1.000	0.000
	Apple iPhone 4	30	5.93	0.907			
Error Messages Unhelpful-Helpful	Acer Inconia Tab	30	6.07	1.437	0.619	0.541	0.100
	Apple iPhone 4	30	5.97	1.299			
Prompt Messages Confusing-Clear	Acer Inconia Tab	30	6.10	0.885	2.276	**0.030	0.333
	Apple iPhone 4	30	5.77	1.223			
Message Positions Inconsistent-Consistent	Acer Inconia Tab	30	6.33	0.711	1.278	0.211	0.133
	Apple iPhone 4	30	6.20	0.761			
Related Terms to the Task Never-Always	Acer Inconia Tab	30	6.17	0.747	0.902	0.375	0.100
	Apple iPhone 4	30	6.07	0.868			
Informs About Work Progress Never-Always	Acer Inconia Tab	30	6.27	0.691	1.606	0.119	0.433
	Apple iPhone 4	30	5.83	1.440			
Category: Learning							
Learning Method Helpful-Unhelpful	Acer Inconia Tab	30	6.13	0.819	0.297	0.769	0.033
	Apple iPhone 4	30	6.10	0.845			
Help Messages Helpful-Unhelpful	Acer Inconia Tab	30	5.90	1.373	1.355	0.186	0.333
	Apple iPhone 4	30	5.57	1.851			
Tasks Can be Performed in Straight-Forward Manner Never-Always	Acer Inconia Tab	30	5.87	1.332	0.000	1.000	0.000
	Apple iPhone 4	30	5.87	1.432			
Remembering Commands Difficult-Easy	Acer Inconia Tab	30	6.17	0.834	1.409	0.169	0.167
	Apple iPhone 4	30	6.00	0.910			
Learning to Operate the System Difficult-Easy	Acer Inconia Tab	30	6.40	0.770	2.449	**0.021	0.400
	Apple iPhone 4	30	6.00	1.083			
Information Delivery Method Helpful-Unhelpful	Acer Inconia Tab	30	6.17	0.699	1.720	0.096	0.333
	Apple iPhone 4	30	5.93	0.828			
Category: Application capabilities							
System Speed Too Slow-Fast Enough	Acer Inconia Tab	30	6.33	0.802	1.795	0.083	0.300
	Apple iPhone 4	30	6.03	1.033			
System Reliability Unreliable-Reliable	Acer Inconia Tab	30	5.93	1.741	2.757	**0.010	0.300
	Apple iPhone 4	30	5.63	1.712			
Showing Your Mistakes Never-Always	Acer Inconia Tab	30	5.93	1.780	-0.126	0.901	-0.033
	Apple iPhone 4	30	5.97	1.450			
Experienced and Inexperienced Users' Consideration Never-Always	Acer Inconia Tab	30	5.57	1.695	0.239	0.813	0.033
	Apple iPhone 4	30	5.53	1.756			

** $P<0.05$

TABLE II.
RESULTS OF USERS' SATISFACTION TOWARDS THE TWO MOBILE SCREEN INTERFACES

Terms	**Results in Pair Sample T-Test (Note: Acer Inconia Tab=Table PC; Apple iPhone4=mobile phone)**
Terrible-Wonderful	Significant difference for Tablet PC (M=5.97, SD=0.809) and mobile phone (M=5.17, SD=1.020) conditions, t(29)=4.558, **P value=0.000.
Difficult-Easy	Significant difference for Tablet PC (M=6.30, SD=0.794) and mobile phone (M=5.63, SD=1.159) conditions, t(29)=2.878, **P value= 0.007.
Frustrating-Satisfying	Significant difference for Tablet PC (M=6.13, SD=0.900) and mobile phone (M=5.07, SD=1.437) conditions, t(29)=4.136, **P value= 0.000.
Ineffective-Effective	Significant difference for Tablet PC (M=6.00, SD=0.910) and mobile phone (M=5.67, SD=0.959) conditions, t(29)=2.763, **P value= 0.010.
Inefficient-Efficient	NO significant difference for the two mobile devices, t(29)=-0.843, P value=0.406. The mobile phone is more efficient than the Tablet PC.
On Screen Information	Significant difference for Tablet PC (M=6.20, SD=0.961) and mobile phone (M=5.77, SD=0.971) conditions, t(29)=2.765, **P value=0.010.
Interaction	Significant difference for Tablet PC (M=6.20, SD=0.761) and mobile phone (M=5.23, SD=1.406) conditions, t(29)=3.593, **P value=0.001.
Reading Items	Significant difference for Tablet PC (M=6.33, SD=0.802) and mobile phone (M=5.03, SD=1.497) conditions, t(29)=4.227, **P value=0.000.
Navigate Among the Screen	Significant difference for Tablet PC (M=6.30, SD=0.750) and mobile phone (M=5.67, SD=1.241) conditions, t(29)=2.670, **P value=0.012.
Simple and Natural Sentences	NO difference for both mobile devices, t(29)=0.000, P value=1.000. In this condition, both devices are equal.
Prompt Messages	Significant difference for Tablet PC (M=6.10, SD=0.885) and mobile phone (M=5.77, SD=1.223) conditions, t(29)=2.276, **P value=0.030.
Tasks Can be Performed in Straight-Forward Manner	NO difference for both mobile devices, t(29)=0.000, P value=1.000. In this condition, both devices are equal.
Learning to Operate the System	Significant difference for Tablet PC (M=6.40, SD=0.770) and mobile phone (M=6.00, SD=1.083) conditions, t(29)=2.449, **P value=0.021.
System Reliability	Significant difference for Tablet PC (M=5.93, SD=1.741) and mobile phone (M=5.63, SD=1.712) conditions, t(29)=2.757, **P value=0.010.
Showing Your Mistakes	NO significant difference for both mobile devices, t(29)=-0.126, P value=0.901. The mobile phone is more efficient than the Tablet PC.

** P<0.05, df=29

VI. DISCUSSION

This study focuses on students' usability satisfaction for mobile-based learning prototype based on the impacts of two different mobile devices for learning a technical subject called Dijkstra's shortest path algorithm. With this goal in mind, we investigated and compared the impacts of these two mobile devices on the level of user satisfaction employing the QUIS usability questionnaire to compare tablet PCs (Acer Inconia Tab) with mobile phones (Apple iPhone 4).

All users worked with the same mobile-based learning prototype and performed the same task each learning and testing session. In general, the Acer Inconia Tab with its bigger screen size, faster reaction, and better clarity of the contexts gained higher scores as compared to Apple iPhone 4 mobile phone in terms of '*overall reaction to the application*', '*screen', 'terminology and system feedback'*, '*learning and application capabilities'*. This falls within our expectations as tablet PCs generally have a larger screen display (1280 x 800 pixels) than mobile phones (640 x 960 pixels) that triggers a better system reaction and performance for users interacting with the tasks at hand.

This study examined user satisfaction with both mobile devices for learning a technical subject. Results show that the Acer Inconia Tab and Apple iPhone 4 share the same score in terms of *"simple and natural sentences"* and *"task can be performed in a straight-forward manner"*. However, it is interesting to learn that the Apple iPhone 4 gained better satisfactory scores in terms of *"efficiency"* and "*showing the mistakes*" on the basis of user satisfaction questionnaire. The feedback gathered indicates that the Apple iPhone 4 could be more portable, attractive and responsive in showing errors. Apart from the above mentioned 4 items, the Acer Inconia Tab generally scored better for overall items as compared to Apple iPhone 4.

Based on the finding of this research study, we recommend "*if a learning application is to be developed based on mobile phones, there are some factors that should be considered by the designers and developers. Users must be able to change the screen size of the application. The application should be able to tilt to a landscape size by the users*".

The small size of the buttons and texts, the lack of sound effects and landscaping ability of the prototype, and the changing size of the screen are the main reasons the learning prototype was not preferred, and users were not satisfied with the prototype when presented through the mobile phone.

VII. CONCLUSION

The goal of this research was to investigate and compare the impacts of different mobile devices on user satisfaction among computer science students learning Dijkestra's shortest path algorithm. We noticed that the Acer Inconia Tab, representative of the tablet PC family, is found to be more useful in learning Dijkestra's shortest path algorithm than the Apple iPhone 4, an example of the touch-based mobile phone family. Users were more satisfied using the tablet device than a mobile phone because of the tablets' larger screen size and the better clarity of information presented. Significantly, however, participants perceived that the mobile phone was more efficient as the results of QUIS questionnaire show that the efficiency of the mobile phone was greater than that of the tablet PC.

Generally, the two mobile devices were presented as a testing tool for computer science students to learn a technical subject and measure their usability level and impacts on user satisfaction scores. Therefore, it is important to investigate the level of user satisfaction of the two mobile devices based on different sizes of screen interface. Apart from this, *interactivity, multimedia elements* and *usable system feedback* are three factors that improve user satisfaction results and make better engage students to interact with the application. Consequently, it is important the content shown on the tablet PCs with bigger screen size to be interactive and simple to provide users greater control of the application to stimulate their learning process.

In conclusion, future research is essential to investigate the impacts of small screen interfaces on user satisfaction. The first of this study's 3 groups learned a specific technical subject in a face-to-face classroom, the second group of students learns the subject using tablet PCs and the third group of students learned the subject with a combination of face-to-face classrooms and tablet PCs. Future study will include performing a single test and evaluate each group of students to figure out which approach or technology has the greatest user satisfaction. Future research will also include an Internet-based mobile learning application to provide a more robust interaction between lecturers and students that better communicates students with fewer time and location constraints.

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